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Working hours, sleep, and fatigue in the agriculture, forestry, and fishing sector: A scoping review

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Abstract

Introduction: Agriculture, forestry, and fishing industry (AgFF) workers often work extremely long hours during peak production seasons, resulting in sleep deprivation and fatigue. The National Occupational Research Agenda has classified fatigue as a "significant safety issue" and area of concern for many industry sectors, including AgFF. This review explores current research and practice in AgFF and proposes next steps.

Methods: We conducted a scoping literature review to examine the extent and nature of research in this area. Article inclusion criteria included peer-reviewed journal articles written in English;

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AUTHOR CONTRIBUTIONS

K. C. Elliott and Jennifer Lincoln created the review criteria along with feedback from Laura Syron (in acknowledgments). Screening and selection of texts were finalized by K. C. Elliott and Jennifer Lincoln, as well as an initial draft with feedback from Laura Syron (in acknowledgments). Michael Flynn, Jeffrey Lavin, Mathew Smidt, Jerry Dugan, and Athena Ramos reviewed search results and revised critically for important intellectual content. Subsequent revisions were completed by K. C. Elliott and Jennifer Lincoln and then reviewed again by Michael Flynn, Jeffrey Lavin, Mathew Smidt, Jerry Dugan, and Athena Ramos.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

ETHICS APPROVAL AND INFORMED CONSENT

There was no ethics review and approval/or consent as this is a review of the literature.

DISCLAIMER

The findings and conclusions in this review are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

published after 1989; covering AgFF workers in high-income countries; with data on working hours/schedules and sleep related to safety and health.

Results: Limited research has addressed long hours and sleep deprivation among AgFF workers. We identified 8350 articles for title and abstract review. Among those, 407 underwent full-text review and 96 met all inclusion criteria (67% agriculture, 25% fishing/seafood processing, 8% forestry). The literature provided some evidence fatigue contributes to fatalities, injuries, and illnesses in AgFF. Older, new, young, foreign-born, and female workers, as well as those who work in small organizations or longer hours (40+) may be at higher risk for fatigue-related injury and illness. Few studies have developed or evaluated interventions to control risks.

Discussion: Given that fatigue is a factor in injury and illness for this sector, future AgFF surveillance and research should increase efforts to capture fatigue and sleep data, directly investigate the role of long hours and nonstandard work schedules in the sector, and most importantly, create practical interventions to manage fatigue.

Keywords

agriculture; aquaculture; commercial fishing; extended shift; fatigue; forestry; irregular schedules; seafood processing; sleep; work hours

1 | INTRODUCTION

The agriculture, forestry, and fishing (AgFF) industry sector has approximately 2.4 million workers.[1] Agriculture includes both crop and animal production, as well as animal products such as milk and eggs. Forestry includes logging operations and businesses that grow trees and gather forest products. Fishing includes a variety of commercial fishing operations offshore and onshore. AgFF workers face serious safety and health challenges potentially compounded by long hours, limited sleep, and fatigue. AgFF has the highest fatal injury rate among all industry sectors, at 23.4 per 100,000 full-time equivalent workers (FTEs), over six times higher than the all-worker rate of 3.5 per 100,000 FTEs.[2] Likewise, AgFF workers are at high risk for nonfatal injury and illness, with a rate of 5.3 per 100 FTEs, compared to the all-worker rate of 2.8 per 100 FTEs.[3] Furthermore, the nonfatal injury and illness rate likely severely underestimates the true injury and illness burden in this sector, due to limitations in reporting and methodology of surveying employers (e.g., exclusion of self-employed workers, which constitute a significant portion of this workforce).[4] At the same time, most AgFF workers are specifically exempted from policies regulating maximum hours per shift, overtime pay, minimum wage, child labor restrictions, as well as health and safety enforcement.[5–7]

Across the AgFF sector, long work hours and fatigue-related injury and illness have been identified as topics of concern. In 2008, the National Occupational Research Agenda (NORA) for AgFF stated fatigue was a “significant safety issue” and is a “cultural norm.”[8] The current NORA for AgFF also described it as an area of concern and includes a priority to explore risk factors for fatigue and to develop interventions.[9] US agriculture workers do work longer hours on average, but hours can vary by the type of commodity produced and by season. The National Agricultural Workers Survey reported that in 2015–2016,

agricultural crop production workers on average worked 38–54 h/week[10]; whereas, the national average for all US workers was 34.5 h/week.[11] In 2019, agriculture and related industry full-time workers on average worked 47.6 h/week compared to 42.5 h/week for nonagricultural workers, and 19.3% of agriculture workers reported 60 h or over per week compared to 6.4% of nonagricultural workers.[12]

Studies have shown overtime, extended work shifts, and lack of sufficient sleep are known risk factors for injury and illness.[13] For example, workers who lack sufficient sleep are at higher risk of vehicle crashes, obesity, psychological disorders, musculoskeletal disorders, reproductive problems, diminished immune response, and chronic disease.[14–17] Fatigue, as a result of long hours and sleep deprivation, leads to decreases in cognitive performance which may affect attention, executive function, reaction time, short-term memory, and other factors.[18–28]

The National Institute for Occupational Safety and Health (NIOSH) is dedicated to reducing the health and safety risks associated with shift work, long work hours, and other sources of fatigue. NIOSH has facilitated a variety of teams to identify research gaps/needs related to working hours, sleep, and fatigue in industries across the US. This manuscript is part of series of papers developed following the NIOSH Working Hours, Sleep and Fatigue Forum on September 13–14, 2019.[29] The objective of this scoping review was to identify available occupational safety and health research related to extended working hours, sleep deprivation, and fatigue-related injury and illness in the AgFF industry through a scoping literature review. Moreover, this paper identifies key cross-industry issues and knowledge gaps and suggests future research directions to identify effective fatigue-mitigation interventions tailored to the AgFF industry.

2 | METHODS

As our goal for this review was to gather, describe, and categorize available research on work hours, sleep, and fatigue specifically within the AgFF sector, we conducted a scoping review informed by methodology described in Arksey and O'Malley, Peters et al., and Munn et al.[30–32] Scoping reviews, while often still rigorous and replicable, focus on a broader topic rather than an individual research question (or questions).[32] Likewise, scoping reviews seek to characterize the available types of research data, describe/contextualize key concepts and factors, and propose future research areas related to the topic; however, they do not generally go on to assess strengths or weaknesses in the methodology of individual articles as in a systematic review.[31,32] Our scoping review process included the following steps: (1) developing case definition and inclusion/exclusion criteria; (2) conducting an initial pilot search to identify keywords and representative papers; (3) identifying relevant studies through a title and abstract search; (4) selecting studies for a full-text review; (5) recording relevant attributes of the papers; (6) collating, summarizing, and reporting results. The research team was comprised of individuals familiar with the various aspects of the agriculture, forestry, and fishing sector, epidemiology, and literature synthesis. The team worked with Centers for Disease Control and Prevention librarians to finalize search terms and selection of databases to search.

2.1 | Case definition

We first defined fatigue as a decrease in mental or physical ability as a result of irregular schedules, extended work hours (8 or more hours worked in a shift), and/or sleep deprivation (sleeping less than recommended[33] sleep duration). Self-reported feelings of "fatigue," "tiredness," "sleepiness," and other related terms were included, as were studies in which participants' fatigue/sleepiness was quantifiably measured (e.g., Epworth Sleepiness Scale). Studies that did not specify the source of fatigue (physical labor, sleep deprivation, work schedule) were included in the review. Articles with discussions of fatigue in relation to factors which did not result in longer hours or irregular schedules (vibration, noise, pesticide, or chemical exposure, etc.) were excluded. While these factors are important areas of study, our focus was specifically to look at the effects of work hours (extended, irregular, early/late start) on fatigue and adverse outcomes. The search terms included: Sleep* OR ("work" within five words of "shift*") OR fatigue* OR exhaustion OR tired OR work schedule OR (work* ADJ5 hour*) OR wakefulness OR rotating shift* OR (long* ADJ5 hour*). The AgFF industry included any industry subsector listed under North American Industry Classification System (NAICS) code 11, as well as seafood processing (NAICS 3117) due to it occurring on fishing vessels. Our search terms included Fishery OR Fisheries OR Fish processing OR fish processor* OR seafood processing OR seafood processor* OR agriculture OR agricultural OR poultry production OR egg production OR commercial fishing OR fishermen OR (fishers NOT (fishers ADJ2 test*) OR forestry OR logging OR aquaculture OR mariculture OR crop production OR farming OR farmer* OR farm-hand* OR farmhand* OR farm work* OR ranch*).

Concurrently, seven databases were searched for publications during the years 1990–2019: Medline, Embase, PsychInfo, CAB Abstracts (OVID), Scopus, Agricultural and Environmental Science Collection (ProQuest), and Web of Science. All records were then placed into EndNote X9 bibliographic management software[34] and uploaded into Covidence,[35] an online systematic review management software. Duplicates were automatically removed.

2.2 | Inclusion/exclusion criteria

Peer-reviewed papers, regardless of study design, were included. We did not include gray literature such as presentations, unpublished reports, trade journal articles, or government documents. Articles were written in English; published 1990–2019; covering AgFF workers (NAICS 11) or Seafood Processors (NAICS 3117), from high-income countries as defined by the World Bank[36] which generally more closely resemble US industry practices; and included data on working hours, schedules, sleep, and reported feelings of fatigue-related terms, for example, "fatigue," "tiredness," "sleepiness," or other related terms as they relate to worker safety and health.

2.3 | Analysis

Articles were reviewed by three study team members. After two recorded the same decision, the article was put through to the next step or removed. If, however, the decision was not the same, the third reviewer resolved the conflict. If the third reviewer could not resolve the conflict, it was decided by consensus among the three reviewers. Full-text review

of articles was completed in the same fashion. Relevant data were then extracted and subsequently categorized by industry subsector, year, country, study design, key findings, common themes, possible interventions, identified research gaps, and recommendations for future research.

3 | RESULTS

The initial search returned 9217 articles to which we added 66 articles from the pilot review, plus one article from a search of the reference sections in our pilot review. This yielded a total of 9284 articles. Using the Covidence application, 934 duplicates were automatically removed, leaving 8350 articles for title and abstract review. Among those, 407 were determined to be relevant and underwent full-text review. After the full-text review, only 96 met all inclusion criteria. The other 311 were rejected in accordance with the exclusion criteria: 208 not pertaining to relevant exposure and outcomes, 70 incorrect worker population, 17 not a peer-reviewed article, 9 duplicate, 3 unable to obtain copy of full text, 2 not in English, and 2 before 1990 (Figure 1).

By industry, 64 articles referenced agriculture and none in aquaculture (67%), 22 referenced fishing and 2 seafood processing (25%), and 8 in forestry (8%). By study design, there were 58 cross-sectional, 10 cohort, 10 qualitative, 6 literature reviews, 3 case control, 3 mixed methods, 3 interventional, 2 editorials, and 1 theoretical (model). By country, 45 papers featured workers in the United States, 45 were outside of the United States, and 6 were multi-country or global in scope. Overall, the review confirms there has been little research specifically on work hours, sleep, and fatigue in the AgFF sector compared to other sectors. Most articles did not focus on sleep deprivation, work hours, or work schedules among AgFF workers, but instead discussed fatigue in the context of a broader investigation of occupational injury and illness. Twenty-two studies included quantitative data on work hours and sleep in relation to injury and are included in Table 1; however, these studies relied on self-report surveys and interviews and mainly focused on farm owners and farm households. There were no studies in industries other than crop and livestock production agriculture. While a few studies focused on younger farm workers[37–39] and older owners/workers,[40,41] only two of the studies focused on migrant/immigrant populations.[39,42]

3.1 | Evidence of injury and illness

The review did provide some quantitative evidence of long work hours, insufficient sleep, and sleep disorders contributing to increased injury and illness in the AgFF sector specifically, but not in all studies[43] (see Table 1). For work hours, studies generally indicated that with an increase in hours, injuries increased[44–49]; however, some studies showed a decreased rate at higher hours.[50,51] Four studies captured reports of insufficient sleep (less than 8 h of sleep per night), and all found increased risk of injury[37,39,51,52] or back pain.[42] Of the three studies which measured sleepiness using the Epworth Sleepiness Scale, two studies did not find a statistically significant risk of injury,[53,54] and one study found a score of >10 to be protective.[43] For sleep disorder, studies found increased risk of injury for those who reported symptoms of sleep apnea[40,41,51,52,55] or used sleep medication[51], but one study found decreased risk for those who reported diagnosed sleep apnea.[55]

In agriculture, long hours and fatigue were thought to be risk factors for injury and illness.[37,44,45,47–50,53,56–62] Sleep disorders[63] and increased work hours,[64,65] were associated with depression. A survey of farmers in the United Kingdom found they believed fatigue was the main factor in quad-bike (four-wheeler) loss-of-control incidents,[56] and a survey of farmers in the United States found "hurry, fatigue, and stress" to be the top reasons for a work-related injury.[66] Other effects of sleep loss/poor sleep in the agriculture industry included decreased balance,[67] weakened hand grip,[68] and a weak relationship between self-reported ill health and daytime sleepiness.[69] Among loggers, self-reported near-miss injury reports were more common among those also reporting a "high level" of fatigue.[70] In a series of interviews with loggers in Idaho, respondents reported "production pressure, fatigue, and inexperience as the most common factors contributing to logging injuries" with "working long hours, long commutes, and few days off" as the most frequently stated reasons for participants feeling fatigue.[71] Reviews of fishing industry literature identified only a few articles and proposed fatigue as a major factor in fishing vessel disasters,[72,73] but much more research is needed to thoroughly understand the impact of fatigue on vessel disasters and what can be done to mitigate it.[74] Fishing industry[75,76] studies also reported a high prevalence of obesity which may be related to fatigue.

3.2 | Cross-cutting issues

We identified several issues across AgFF industries which may contribute to fatigue: extended work hours and irregular schedules, economic and organizational factors, housing and psychosocial factors, and co-occurring health disparities (older workers, new workers, young workers, foreign-born workers, female workers, and workers in small operations). Across all sectors, few studies developed or evaluated interventions to control risks, but recommendations for possible interventions and future research were identified.

3.3 | Work hours/schedule

The review confirmed workers in the AgFF sector often work long hours (sometimes up to 16+ h per day) and experience fatigue, especially during peak harvest and production seasons.[48,75,77–85] Operations frequently run 24-h per day, and shift work is prevalent, especially in forestry[86] and seafood processing.[77,78] The seasonal nature of AgFF work can contribute to fatigue in various ways. Light and darkness can negatively affect workers because they primarily work outside.[86] Exposure to heat[87] and cold stress may also increase fatigue due to physiological energy expenditures, or start shifts earlier or later to avoid extreme conditions. Harvests are frequently dependent on weather, which often results in working longer hours when the weather is good or when there is impending bad weather. Bell and Helmkamp found logging worker compensation claims in West Virginia (1995–2001) steadily increased from January to September and then decreased for the rest of the year, which the authors attribute to working longer hours in late summer to ensure sawmills would be supplied through winter.[89] However, Lilley et al. found while decreased sleep during peak production times did not increase risk for injury, those who slept less than 5 h during *nonpeak* production times were at increased risk of injury (OR: 2.42, 95% CI: 1.04–5.59).[52] Authors found working irregular schedules may contribute to injuries[89] and mental health disorders[65] among fishermen.

3.4 | Organizational and economic factors

Economic and time pressures related to seasonal peaks (e.g., planting, harvesting) may result in shortcuts and working despite high levels of fatigue. Some articles noted that workers in the AgFF sector are often paid by how quickly they work (piece-rate) and/or the size of the harvest, leading to fast-paced work, long hours, and less sleep.[90] Lizer and Petrea found while increased hours among older farmers did not increase injury risk, financial stress did.[91] Increased hours working with animals also was a risk factor,[45,46] but studies did not specifically compare extended schedules (40+ h/week) to handling livestock. Fishermen often work irregular and extremely long shifts during harvests.[89] When stocks are depleted, fishermen must travel further and log longer hours for harvests.[92,93] Farmers facing economic difficulty may understaff, diversify their business,[94] and work at night,[95] leading to increased hours, burnout, and depression. Farm workers may start at earlier times to avoid the hottest part of the day, but this may lead interfere with natural circadian rhythms leading to less sleep.[96]

3.5 | Housing, family, and psychosocial factors

AgFF workers often live where they work, or commute long distances to and from remote worksites.[71] Living and working in the same place means it is often hard to truly be "off the clock" and disengage from work, especially for crewmembers at sea who cannot "walk-off" the vessel to escape worksite stressors.[77,93] At the same time, many workers in the sector work weeks, even months away from family, which several studies reported as a stressor.[85,92,93,97] On family farms, owner/operators,[51] their spouses, or their older children may work an additional job off the farm, which was shown to increase risk of injury.[98,99] Children who work on farms may be more sleep-deprived than their nonfarm peers.[100] Women who live on farms may work especially long hours as they may work an additional job off the farm, and help out on the farm, in addition to household/child-rearing duties.[101] Farm owner-operators' and their spouses who worked longer hours were more likely to say their children were involved in activities/tasks which are known causes of farm injury.[80] Fishermen and offshore seafood processors sleep aboard vessels and may be bothered by vibration, noises, and constant moving of the working platform.[76] Likewise, agricultural workers and onshore seafood processors often live onsite, and congregate housing conditions can contribute to poor sleep and fatigue, especially with poor or cramped housing conditions.[75–77,90,102,103] However, one study found fishermen working 6-h shifts for up to 3 months did not show signs of increased physiological stress via cortisol, blood pressure, and blood lipids, but attributed the findings to "regular working hours, regular healthy meals, predictable tasks, and social well-being on board, as well as healthy worker affect."[104]

3.6 | Co-occurring health disparities

Among AgFF workers, there are disparities related to work hours, sleep, and fatigue among older workers,[75,105–108] younger workers,[37,39,98,100] new workers,[71,86] and foreign-born workers[96,102,108,109] putting these populations at higher risk for fatigue related injury and illness. Lizer and Petrea found older farmers worked longer hours than expected compared to those age 55+ in other occupations, especially during the spring and fall seasons,

averaging 10–12h days,[105] but longer work hours were not associated with increased injury in the same sample.[91] However, in other studies, decreased sleep duration[111] and "restless" sleep[41] in older farmers was associated with increased risk of injury. For adolescent agricultural workers, lack of sleep[39] and holding multiple jobs[98] had increased rates of injury. Psychosocial problems such as stress, anxiety, depression,[63,65,112] and family separation[84,96] for extended periods also play a part in sleep deprivation and fatigue, with these potentially being more prevalent among foreign-born workers.[97,109] One study of migrant workers found 45% experienced elevated depressive symptoms and 20% excessive sleepiness.[109] Migrant farm workers with extended shifts had significantly more hand problems,[64] and those who slept less than 8 h were at increased risk of chronic back pain.[42] Female workers reported more daytime sleepiness than men in one study.[109]

3.7 | Interventions

For the logging industry, multiple studies showed a reduction in productivity for both extended shifts and second/third shifts,[86,113] which resulted in some companies eliminating extended shifts as an economic measure, but not for safety reasons.[86] However, during night shifts, logging companies increased lighting and purchased two-way radios in an effort to increase visibility and communication after dark.[86] Another logging industry study evaluating caffeine intake and comparing shift work found caffeine consumption can reduce risks but had "little benefit for a night of no sleep after a buildup of severe sleep debt".[114] Another study found access to air-conditioning was a key factor in better sleep quality when looking at housing quality of Latino farmworkers.[103] A study of attitudes and beliefs among Vietnamese shrimp fishermen in the Gulf of Mexico demonstrated fatigue was a perceived risk factor and risk perceptions could be altered by knowledge and awareness of interventions influencing intent to change behavior.[115]

The two studies in this review that evaluated the effectiveness of fatigue interventions showed mixed results. Bowen et al. hoped to use real-time monitoring technology to measure fatigue in the logging industry, but found, "it may not be possible to identify correlations between workloads and fatigue measures using in-situ measurements as results are highly personalized to individual workers and can be misleading if the wider context is not also taken into consideration."[116] On the other hand, Levin et al. found "[s]imple, yet culturally appropriate training and awareness measures in the form of visual and written safety messages favorably influence attitudes, beliefs, and behavioral intent related to priority risk factors."[115] These safety messages included a fatigue awareness message as fatigue was a primary concern of one study subgroup.[115]

3.8 | Research gaps and possible interventions

In all industries, the lack of both data and existing interventions for fatigue were mentioned, with a consensus that workers were aware of the hazards and realize the risks, but both the nature of the work and the organizational culture of AgFF industries are barriers to fatigue mitigation.[117,118] Studies also mentioned a need for quality surveillance data to better understand the potential adverse outcomes of extended hours,[57,89] irregular schedules, sleep disorder/deprivation[119] on injury and illness specifically in AgFF. Screening for sleep disorders to improve sleep quality was mentioned.[63,75] Further exploration of the

relationship between sleep and injury and illness specifically for this sector was a suggested topic of future research.[63,120–123] Suggestions for future research also focused on targeting interventions,[49,124] the effect of mood disorders on fatigue and injury,[125] exploring the relationship of policies and regulations,[126] and testing a causal link between vessel disasters and fatigue.[74]

Studies stressed interventions must address the effects of long hours and fatigue, not necessarily create prescriptive rules in an effort to prevent it.[90,117,127,128] Suggested interventions included focusing training on near misses,[129] scheduling targeted fatigue and safety training,[66] especially before or outside of busy times of the year,[56] promoting awareness of problematic social norms which encourage longer hours and fatigue,[94] adopting best practices from other industries,[81] and using a community-based approach.[118]

4 | DISCUSSION

Although long work hours, irregular schedules, and fatigue contribute to fatalities, injuries, and illnesses in the AgFF sector, little research has (1) quantified the extent to which they are contributing factors, especially on workers' health over their life course, (2) developed interventions for hazard mitigation, or (3) evaluated existing interventions and programs. Most studies published on the AgFF sector focus on describing or measuring factors which may lead to fatigue, rather than developing and evaluating interventions. However, there is at least one research project on the effects of sleep deprivation in US fishermen currently underway (J. Sorensen, personal communication, August 13, 2020). Also, some government agencies have created educational materials for industry and workers addressing this,[123,130] but there are no evaluations of their effectiveness. As fatigue is a major factor in injury and illness for this sector, future AgFF surveillance and research efforts should expand efforts to capture fatigue and sleep data, better understand fatigue in unique AgFF workspaces, and most importantly, create practical interventions to manage fatigue.

At the same time, there are significant challenges to collecting data on fatigue in the AgFF sector, such as logistical problems involving the rural and often remote nature of AgFF work, difficulty in how fatigue is conceptualized, measured, and recorded,[131] as well as partnering with small businesses and part-time/seasonal employees. Due to regulatory and organizational barriers, reliable employment numbers, hours worked, and even injury and illness data in this sector are more difficult to obtain.[132] One possible solution could be adding questions on sleep habits and work schedules to existing and future surveys of worker demographics and employment, such as the USDA's National Agricultural Statistics Service (NASS) surveys and the DOL National Agricultural Workers' Survey (NAWS). Incident, injury, and near-miss reports should clearly and specifically ask questions about hours worked, time of day, feelings of fatigue, hours of sleep, and related information to better document the role of fatigue as a risk factor for injury in this sector. Likewise, commute times to and from workplaces should be documented and factored into hours worked, even though they are often unpaid.

Future research must also address the unique nature of work in AgFF, workers' economic and psychosocial stressors (e.g., substandard housing, extended family separation), as well

as the pervasive attitude that working long hours or with fatigue is to be expected, even valued or rewarded. Regulatory and employer policies which incentivize working extended shifts should also be examined specifically in the unique regulatory context of the AgFF sector, but could draw on existing research[54] and best practices[133] from other occupations such as commercial truck drivers and nurses. Much of the manual labor and high-risk tasks in AgFF are performed by immigrant and foreign-born workers,[134] who have known health disparities and risk factors[135] which put them at higher risk of injury and illness due to fatigue; and therefore, this underserved population is in particular need of study. Likewise, the average age of the AgFF workforce is increasing, and research on the impact fatigue may have on older workers is needed—especially interventions which specifically and appropriately focus on this population.[108]

Community-based participatory research may also help to better understand and overcome the many systemic barriers such as regulatory, organizational, and work culture to addressing risks. Increased access to medical care and sleep disorder testing may also mitigate risk of fatigue.[63] Anecdotal evidence from researchers and safety practitioners suggests AgFF workers use caffeine, energy drinks, and so on, or even prescription or illegal drugs to manage fatigue, but has not been studied. Many offshore fishing vessel profits are generally based on the value of the catch minus vessel expenses and then divided into “crew shares” and distributed. This often leads to smaller crews and longer work hours for the crew who remain.[9] In both agriculture and seafood processing, some workers are paid by piece rate, and more research is needed on the effects of this administrative policy. Finally, there are no federal regulations mandating rest times, watchkeeping standards on vessels, or minimal levels of staffing for this sector, except for some of the largest of commercial fishing vessels.[136] The effect of regulatory policy/agricultural exemptions, on work hours, sleep, and fatigue is another area of needed research. Finally, more research is needed to develop practical, relevant fatigue recognition indices and management strategies, and evaluate existing interventions.

Future interventions to address fatigue must move past generalized training on healthy sleep habits and the dangers of fatigue. Stakeholders have noted AgFF workers typically expect and are resigned to long work hours, sleep deprivation, and fatigue as an inevitable and ubiquitous hazard. To address this expectation, peer-to-peer and culturally competent education should be implemented to more effectively address AgFF’s unique culture and work environments. To develop and evaluate practical fatigue risk management strategies, however, researchers and practitioners cannot focus solely on educational/awareness efforts. They must also address the economic and structural influences on workplace organization, established culture and beliefs, and psychosocial factors that increase fatigue-related risks. Interventions which use the principles of harm reduction and social marketing to address long hours and fatigue may prove beneficial. Research assisting AgFF stakeholders in addressing this culture of resignation and reward, and providing practical solutions to manage fatigue, particularly during peak seasons, could lead to a change in work organization and processes, policies, and regulations, which ultimately may prevent fatalities, injuries, and illnesses among these high-risk workers.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

APPENDIX

Search terms:

(Fishery OR Fisheries OR Fish processing OR fish processor* OR seafood processing OR seafood processor* OR agriculture OR agricultural OR poultry production OR egg production OR commercial fishing OR fishermen OR (fishers NOT (fishers ADJ2 test*)) OR forestry OR logging OR aquaculture OR mariculture OR crop production OR farming OR farmer* OR farm-hand* OR farmhand* OR farm work* OR ranch*)

AND

Sleep* OR (work ADJ5 shift*) OR fatigue* OR exhaustion OR tired OR work schedule OR (work* ADJ5 hour*) OR wakefulness OR rotating shift* OR (long* ADJ5 hour*)

NOT

exp animals/NOT exp humans/

Limit to English; 1990 -; Abstract Available

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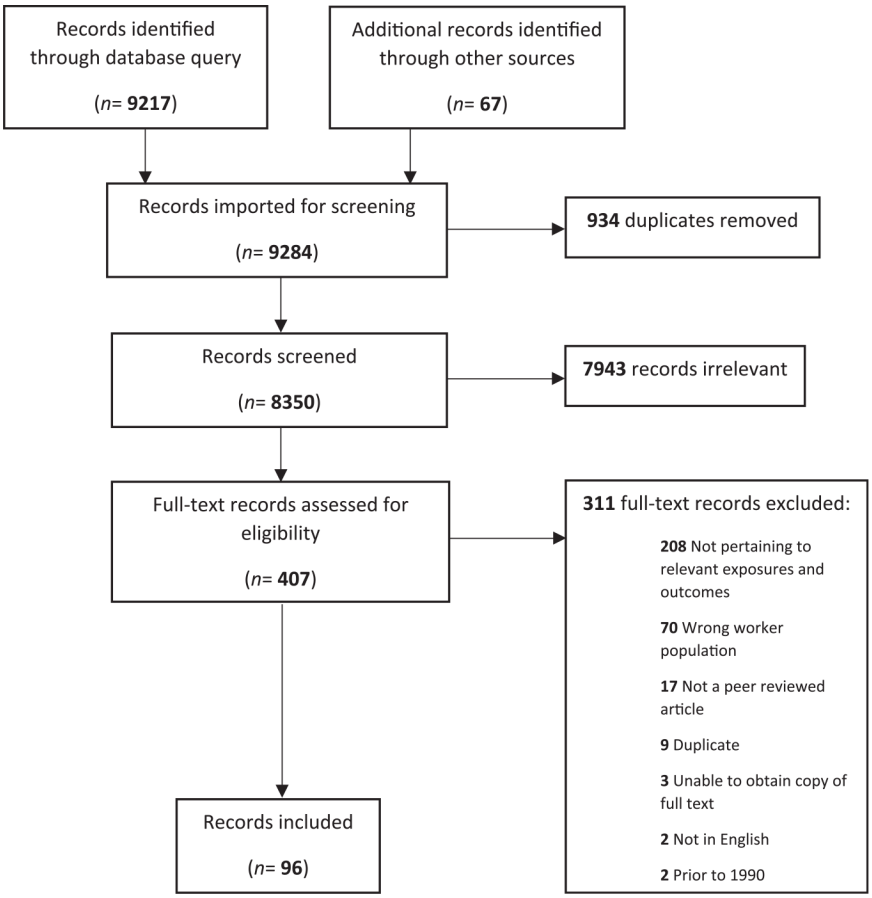

FIGURE 1.
Scoping literature review process

TABLE 1

Work hours and sleep in relation to injury

Study	Year	Sample	Country (region)	Population description	Method of report	Stated study focus	Findings related to work hours, sleep[a]
Work hours							
Browning	2013	1149	USA (Kentucky)	Beef cattle operators and workers	Self-report (survey)	Cattle-related injuries and farm management practices	OR = 2.01 injury for principal operator when 40+ h/week, 95% CI (1.3–3.24) OR = 1.72 injury for all workers when 36–60 h/week, 95% Cl (1.05–2.81) OR = 2.52 injury for all workers when 60+ h/week, 95% CI (1.55–4.09)
DeWit	2015	1135	Canada (Saskatchewan)	Farm youth and young adults, 12–29[b]	Self-report (survey)	Farm activities and agricultural injuries	Risk ratio = 10.3 injury for hours of farm work, 30+ h/week, 95% CI (2.2–47.5), (p = 0.003)
Erkal	2008	32,602	USA (Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska)	Farm households[c]	Self-report (interview)	Animal-related injuries	Animal-related injury event rates per 1000 persons per year: >40–60 h/week = 55.9, 95% CI (47.0–66.6) >60–80 h/week = 78.5, 95% CI (66.9–92.1) >80 h/week = 100.9, 95% CI (78.4–130.0)
Gerberich	1998	13,144	USA (Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska)	Farm households[d]	Self-report (interview)	Machine-related injuries	Machine-related injury rate per 100,000 persons: 40–59 h/week = 2254, rate ratio: 12.52, 95% CI (6.20–25.29) 60–79 h/week = 3664, rate ratio: 20.66, 95% CI (10.50–40.62) 80+h/week = 2716, rate ratio: 15.16, 95% CI (6.91–33.26)
Heaton	2010	756	USA (Kentucky and South Carolina)	Farmers aged 50 and older[e,f]	Self-report (survey)	Sleep apnea indicators and injury	OR = 1.017 injury per 1-h increase in work hours, 95% CI not given (p = 0.0047) (found to be not statistically significant in final multivariable logistic regression model)
Hwang	2001	1706	USA (New York)	Farm owners/workers[g]	Self-report (interview)	Severe farm injuries	OR = 9.54 injury for those working >8 h/day (54.0% of participants), 95% CI (4.48–21.2), (p = <0.0001)
Ichihara	2019	337	Japan	Farm workers	Self-report (survey)	Risk factors for occupational accidents	OR = 1.76 occupational accidents for those working ≥8 h/day, 95% CI (1.15–2.68)
Lilley	2012	4439	Canada (Saskatchewan)	Farm owners/workers aged 16 and older[b]	Self-report (survey)	Relationship between fatigue-related factors and work-related injuries	Percentage of workers injured in peak season by work hours: 30–59 h/week = 6.7%, 60–79 = 9.1%, ≥80 = 10.1% (p = <0.0001) Percentage of workers injured in nonpeak season by work hours: 30–59 h/week = 2.6%, 60–79 = 4.6%, ≥80 = 2.6% (p = <0.001)
McCurdy	2004	135	USA (California)	Farm operators	Self-report (survey)	Nonfatal occupational injury	OR = 2.63 injury farmed 1441–3500 h in the last year, 95% CI (1.43–4.83) OR = 3.77 injury farmed >3500 h in the last year, 95% CI (1.63–8.69)
McCurdy	2012	489	USA (California)	Youth (grades 9–12) enrolled in agriculture sciences curriculum	Self-report (survey)	Risk factors for injury	OR = 5.09 injury for those who worked 1501+ h/year, 95% CI (1.61–16.1)
Paulson	2006	16,538	USA (Minnesota, Wisconsin, North Dakota, South	Farm households[c]	Self-report (interview)	Fall-related injuries	Fall-related injury event rate per 1000 persons per year: >40–60 h/week = 49.2, 95% CI (38.6–62.6)

Study	Year	Sample	Country (region)	Population description	Method of report	Stated study focus	Findings related to work hours, sleep[a]
			Dakota, and Nebraska)				>60–80 h/week = 52.1, 95% CI (40.6–66.8) >80 h/week = 55.6, 95% CI (37.9–81.6)
Pratt	1992	600	USA (New York)	Dairy farm owners/ workers	Self-report (interview)	Risk factors for occupational accidents	Relative risk = 2.76 injury for owners who worked more than 60 h/week and had 30+ acres under tillage/worker. Injured workers were: older (p = 0.01), worked more hours (p = 0.001), and had heavier workloads than noninjured workers (p = 0.001)
Reiner	2016	32,598	USA (Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska)	Farm households[c]	Self-report (interview)	Large machinery-related injuries	Large machine-related injury events per year per 1000 persons: 20–39 h/week = 18.88, 95% CI (14.93–23.88) 40–59 h/week = 40.25, 95% CI (32.83–49.35) 60–79 h/week = 43.15, 95% CI (35.17–52.92) 80+ h/week = 43.19, 95% CI (30.56–61.05)
Spengler	2004	1004	USA (Kentucky)	Part-time farmers age 19 and older[e]	Self-report (interview)	Sleep deprivation and injuries	OR = 1.43 injury for 41–50 h/week, 95% CI (0.73–2.80) OR = 1.02 injury for >50 h/week, 95% CI (0.44–2.39)
Spince	2003	431	USA (Iowa)	Farmers	Self-report (interview)	Risk factors for injury	OR = 1.65 injury for farmers working >50 h/week in the last year, 95% CI (1.23–2.21)
Svendsen	2014	2699	Norway (2 counties)	Farmers	Self-report (survey)	Risk factors for injury	OR = 1.54 injury for working >3500 h at farm, 95% CI not given (p = <0.01)
Insufficient sleep (less than 8h of sleep per night)							
DeWit	2015	1135	Canada (Saskatchewan)	Farm youth and young adults, 12–29[b]	Self-report (survey)	Farm activities and agricultural injuries	9.5% injury rate for ≤6 h sleep per night, CI (6.3–12.6), (p = 0.0002)
Lilley	2012	4439	Canada (Saskatchewan)	Farm owners/workers aged 16 and older[b]	Self-report (survey)	Relationship between fatigue-related factors and work-related injuries	OR = 1.43 injury for 7–6 h per night sleep during peak season, 95% CI (0.96–2.12) OR = 1.48 injury for ≤5 h per night sleep during peak season, 95% CI (0.93–2.34) OR = 1.41 injury for 7–6 h per night sleep during nonpeak season, 95% CI (0.86–2.32) OR = 2.40 injury for ≤5 h per night sleep during nonpeak season, 95% CI (1.02–5.68), (p = 0.04)
Spengler	2004	1004	USA (Kentucky)	Part-time farmers age 19 and older[e]	Self-report (interview)	Sleep deprivation and injuries	OR = 1.01 injury for 7 h/day average sleep past year, 95% CI (0.64–1.59) OR = 1.25 injury for 6 h/day average sleep past year, 95% CI (0.73–2.15) OR = 1.12 injury for ≤5 h/day average sleep past year, 95% CI (0.47–2.64)
Shipp	2009	390	USA (Texas)	Migrant farm worker families	Self-report (interview and survey)	Chronic back pain and associated work and nonwork variables	OR = 2.26 chronic back pain for <8 h/day sleep at home, 95% CI (1.16–8.12), (p = 0.024) OR = 3.25 chronic back pain for fairly bad/very bad quality of sleep while migrating, 95% CI (1.78–10.25), (p = 0.001)
Shipp	2013	410	USA (Texas)	Farmworkers aged 13–19 years	Self-report (survey)	Acute occupational injury	HR = 2.10 injury for <8 per night, 95% CI (1.09–4.04), (p = 0.026)
Epworth Sleepiness Scale (ESS)							

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Study	Year	Sample	Country (region)	Population description	Method of report	Stated study focus	Findings related to work hours, sleep[a]
Day	2009	252	Australia (Victoria)	Farm owners/workers aged 16 and older	Self-report (interview)	Risk factors for work related injury among male farmers	OR = 0.51 injury for ESS > 10, 95% CI (0.32–0.82)
King	2014	2392	Canada (Saskatchewan)	Farm owners/workers aged 16 and older[b]	Self-report (survey)	Impact of excessive daytime sleepiness on safety and health	OR = 1.34 injury for ESS > 10, 95% CI (0.92–1.96)
Spince	2003	431	USA (Iowa)	Farmers	Self-report (interview)	Risk factors for agricultural injury	OR = 1.27 injury for ESS > 15, 95% CI (0.98–1.66)
Sleep disorder (diagnosed and symptoms)							
Dosman	2013	5502	Canada (Saskatchewan)	Farm owners/workers[b]	Self-report (survey)	Loud snoring and occupational injury	HR = 0.79 injury for diagnosed sleep apnea, 95% CI (0.43–1.47) HR = 1.45 injury for loud snoring, 95% CI (1.07–1.99)
Heaton	2010	756	USA (Kentucky and South Carolina)	Farmers aged 50 and older[e,f]	Self-report (survey)	Sleep apnea indicators and injury	OR = 1.861 injury for stop breathing while sleeping, 95% CI (1.035–3.346), (p = 0.038) OR = 2.246 injury for problems staying awake last month, 95% CI (1.244–4.055), (p = 0.007)
Lilley	2012	4439	Canada (Saskatchewan)	Farm owners/workers aged 16 and older[b]	Self-report (survey)	Relationship between fatigue-related factors and work-related injuries	OR = 1.20 injury for loud snoring, 95% CI (0.79–1.83)
King	2014	2392	Canada (Saskatchewan)	Farm owners/workers aged 16 and older[b]	Self-report (survey)	Impact of excessive daytime sleepiness on safety and health	OR = 0.96 injury for diagnosed sleep apnea, 95% CI (0.47–1.96)
Marcum	2011	1394	USA (Kentucky and South Carolina)	Farmers aged 50 and older[e,f]	Self-report (survey)	Injury among farmers 50 years and older	OR = 1.32 injury for 1–2 days restless nights in past week, 95% CI (0.96–1.81), (p = 0.0883) OR = 2.02 injury for 3–4 days restless nights in past week, 95% CI (1.32–3.09), (p = 0.0011) OR = 1.89 injury for 5–7 days restless nights in past week, 95% CI (1.28–2.80), (p = 0.0012)
Spengler	2004	1004	USA (Kentucky)	Part-time farmers age 19 and older[e]	Self-report (interview)	Sleep deprivation and injuries	OR = 2.28 injury for sleep medication used in the past month, 95% CI (1.67–4.47) OR = 2.17 injury for three sleep apnea signs and symptoms, 95% CI (1.03–4.56)

[a] Adjusted values used when available.

[b] Saskatchewan Farm Injury Cohort.

[c] Regional Rural Injury Study II (RRIS-II) Cohort.

[d] Regional Rural Injury Study I (RRIS-I) Cohort.

[e] Kentucky Farm Family Health and Hazard Surveillance Project.

[f] African-American farmers from the Kentucky and South Carolina Agricultural Statistics Services.

[g]New York State Farm Family Health and Hazard Surveillance Project.